Preliminary Feasibility Assessment for High Efficiency, Low Emission Wood Heating In Stevens Village, Alaska

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ABSTRACT

The potential for heating public facilities in Stevens Village, Alaska with high efficiency, low emission (HELE) wood-fired boiler(s) is evaluated for the Stevens Village IRA Council.

Early in 2008, organizations were invited to submit a Statement of Interest (SOI) to the Alaska Wood Energy Development Task Group (AWEDTG). Task Group representatives reviewed all the SOIs and selected projects for further review based on selection criteria presented in Appendix A. AWEDTG representatives visited Stevens Village in July 2008 and information was obtained for the various facilities. Preliminary assessments were made and challenges identified. Potential wood energy systems were considered for the projects using AWEDTG, USDA and AEA objectives for energy efficiency and emissions. Preliminary findings are reported.

SECTION 1. EXECUTIVE SUMMARY

1.1 Goals and Objectives

- Identify facilities in Stevens Village as potential candidates for heating with wood
- Evaluate the suitability of the facilities and sites for siting a wood-fired boiler
- Assess the type(s) and availability of wood fuel(s)
- Size and estimate the capital costs of suitable wood-fired system(s)
- Estimate the annual operation, maintenance and repair costs of a wood-fired system
- Estimate the potential economic benefits from installing a wood-fired heating system

1.2 Evaluation Criteria, Project Scale, Operating Parameters, General Observations

- This project meets the AWEDTG objectives for petroleum fuel displacement, use of hazardous forest fuels or forest treatment/processing residues, sustainability of the wood supply (assumed), community support, and project implementation, operation and maintenance.

- Given the combined annual fuel oil consumption estimate of 8,300 gallons at the water plant/ washeteria and clinic/office building, this project would be considered small to medium in terms of its relative size.

- Medium and large energy consumers have the best potential for feasibly implementing a wood-fired heating system. Where preliminary feasibility assessments indicate positive financial metrics, detailed engineering analyses are usually warranted.

- Cordwood systems are generally appropriate for applications where the maximum heating demand ranges from 100,000 to 1,000,000 Btu per hour. "Bulk fuel" systems are generally applicable for situations where the heating demand exceeds 1 million Btu per hour. However, these are general guidelines; local conditions can exert a strong influence on the best system choice.

- Efficiency and emissions standards for Outdoor Wood Boilers (OWB) changed in 2006, which could increase costs for small systems.

1.3 Assessment Summary and Recommended Actions

Two facilities are included in this report:

1.3.1. Clinic/office building

• Overview. The clinic/office building is a single-story structure of conventional frame construction encompassing approximately 1,200 square feet. It houses the Stevens Village IRA Council offices and Stevens Village health clinic. Heat, via hot water and hot water-to-air heat exchangers, is provided by the boiler system installed in the water plant.

• Fuel Consumption. The fuel consumption at the clinic/office building is undeterminable as heat is provided by the water plant boilers.

• Potential Savings. Annual fuel cost savings are undeterminable as heat is provided by the water plant boilers.

• Required boiler capacity. The estimated required boiler capacity (RBC) to heat the clinic/office building is undeterminable as heat is provided by the water plant boilers.

• Recommended action regarding a cordwood system. No recommended actions are offered regarding a stand-alone wood-fired heating system for the clinic/office.

• Recommended action regarding a bulk fuel wood system. Given the apparently small heating demand, apparent lack of bulk fuel(s), and the probable cost of such a project, a "bulk fuel" system would not be cost-effective for the clinic/office building.

1.3.2. Water plant / washeteria

• Overview. This building is a single-story structure of conventional frame construction encompassing approximately 1,200 square feet. It houses the water treatment plant, laundry and shower facilities. The building is approximately 20 years old and may be scheduled for replacement in the not-too-distant future.

Heat and hot water are provided by three Weil McLain model 676 oil-fired boilers rated at 355 MBH (net, each).

• Fuel Consumption. The water plant/washeteria (which also provides heat to the clinic/office building) reportedly consumes about **8,300** gallons of **#1** fuel oil per year, most of which is used to heat water for treatment for domestic consumption.

• Potential Savings. At the current price of about $5.15 per gallon (June 2008), the cost of fuel oil for the water plant/washeteria is approximately $42,745 per year. The HELE *cordwood* fuel equivalent of 8,300 gallons of #1 fuel oil is approximately **97 cords**, and at $250 per cord represents a potential annual fuel cost savings of $18,495 (debt service and non-fuel OM&R costs notwithstanding).

• Required boiler capacity. Given that most of the oil is used for water heating and treatment, discussion of "required boiler capacity" (for space heating) is moot. However, *if* all the oil *was* used for space heating, the estimated required boiler capacity (RBC) would be approximately **268,049** Btu/hr during the coldest 24-hour period.

• Recommended action regarding a cordwood system. Given the initial assumptions and cost estimates for the alternatives presented in this report, this project appears to fall somewhat shy of being economically viable. However, this is only a preliminary report and the results are not conclusive. A wood-fired heating *will* save money over an oil-fired system, but the financial metrics are not strongly positive. Further consideration by a professional engineer is warranted. (See Section 6)

• Recommended action regarding a bulk fuel wood system. Given the relatively small heating demand, lack of bulk fuel(s), and the probable cost of such a project, a "bulk fuel" system would not be cost-effective for the facilities in Stevens Village

Combined, common heating system

While it may be possible to install a small individual wood-fired boiler at each of the facilities under consideration, a more practical solution would be to install a single, large, centralized heating plant, and then distribute heat to both buildings via hot water and insulated plastic tubing. Even though relatively small, this would be considered a "district heating system," and could have significant advantages over individual installations. This is the model I would propose for these facilities in Stevens Village.

SECTION 2. EVALUATION CRITERIA, IMPLEMENTATION, WOOD HEATING SYSTEMS

The approach being taken by the Alaska Wood Energy Development Task Group (AWEDTG) regarding biomass energy heating projects follows the recommendations of the Biomass Energy Resource Center (BERC), which advises that, "[*T*]*he most cost-effective approach to studying the feasibility for a biomass energy project is to approach the study in stages*." Further, BERC advises "*not spending too much time, effort, or money on a full feasibility study before discovering whether the potential project makes basic economic sense*" and suggests, "[*U*]*ndertaking a pre-feasibility study . . . a basic assessment, not yet at the engineering level, to determine the project's apparent cost-effectiveness*". [Biomass Energy Resource Center, Montpelier, Vermont. www.biomasscenter.org]

2.1 Evaluation Criteria

The AWEDTG selected projects for evaluation based on criteria listed in Appendix A. The Stevens Village project appears to meet the AWEDTG criteria for potential petroleum fuel displacement, use of forest residues for public benefit, community support, and the ability to implement, operate and maintain the project.

NOTE: The potential to sustainably provide adequate supplies of wood from local forests was not positively determined. The assumption that such supplies are sufficient is based on information provided in the original Statement of Interest. If there is any doubt that local supplies of wood are satisfactory, then such a determination must be made before installing a wood-fired heating system.

One of the objectives of the AWEDTG is to support projects that would use clean-burning, energy-efficient wood heating systems, i.e., high efficiency, low emission (HELE) systems.

2.2 Successful Implementation

In general, four aspects of project implementation have been important to wood energy projects in the past: 1) a project "champion", 2) clear identification of a sponsoring agency/entity, 3) dedication of and commitment by facility personnel, and 4) a reliable and consistent supply of fuel.

In situations where several organizations are responsible for different community services, it must be clear which organization(s) would sponsor and/or implement a wood-burning heating project. (NOTE: This is not necessarily the case with the facilities in Stevens Village but this issue should be addressed.)

With manual cordwood systems, boiler stoking and/or maintenance is required for approximately 5 to 15 minutes per boiler several times a day (depending on the heating demand), and dedicating personnel for the operation is critical to realizing savings from wood fuel use. For this report, it is assumed that new personnel would be hired or existing qualified personnel would be assigned as necessary, and that "boiler duties" would be included in the responsibilities and/or job description of facility personnel.

The forest industry infrastructure in/around Stevens Village is not well-developed. Nearly all of the local residents rely on woodstoves as their primary heat source and most people cut their own firewood. Stevens Village is surrounded by forestland, most of which is owned by the local village corporation, or are individual Native allotments. Based on information provided in the original Statement of Interest, it is assumed that wood supplies are sufficient to meet the demand.

2.3 Classes of Wood Heating Systems

There are, essentially, two classes of wood energy systems: manual cordwood systems and automated "bulk fuel" systems. Cordwood systems are generally appropriate for applications where the maximum heating demand ranges from 100,000 to 1,000,000 Btu per hour, although smaller and larger applications are possible. "Bulk fuel" systems are systems that burn wood chips, sawdust, bark/hog fuel, shavings, pellets, etc. They are generally applicable for situations where the heating demand exceeds 1 million Btu per hour, although local conditions, especially fuel availability, can exert strong influences on the feasibility of a bulk fuel system.

Usually, an automated bulk fuel boiler is tied-in directly with the existing oil-fired system. With a cordwood system, hot water or glycol from the existing oil-fired boiler system would be circulated through a heat exchanger at the wood boiler ahead of the existing oil boiler. A bulk fuel system is usually designed to replace 100% of the fuel oil used in the oil-fired boiler, and although it is possible for a cordwood system to be similarly designed, they are usually intended as a supplement, albeit a large supplement, to an oil-fired system. In either case, the existing oil-fired system would remain in place and be available for peak demand or backup in the event of a failure or other downtime (scheduled or unscheduled) in the wood system.

One of the objectives of the AWEDTG is to support projects that would use energy-efficient and clean burning wood heating systems, i.e., high efficiency, low emission (HELE) systems.

SECTION 3. THE NATURE OF WOOD FUELS

3.1 Wood Fuel Forms and Current Utilization

Wood fuels in Stevens Village will generally be in the form of cordwood; there are no sawmill residues or bulk fuel supplies. Firewood is the primary heating fuel in the majority of houses in Stevens Village and most residents cut or process their own firewood.

3.2 Heating Value of Wood

Wood is a unique fuel whose heating value is quite variable, depending on species of wood, moisture content, and other factors. There are also several 'heating values', namely *high* heating value (HHV), *gross* heating value (GHV), *recoverable* heating value (RHV), and *deliverable* heating value (DHV), that may be assigned to wood at various stages in the calculations.

For this report, white spruce cordwood at 30 percent moisture content (MC30), calculated on the "wet" or "green" weight basis, is used as the benchmark. (Black spruce, white birch, aspen and willow are also present and usable as firewood.)

The HHV of white spruce at 0% moisture content (MC0) is 8,890 Btu/lb[1] and the GHV at 30% moisture content (MC30) is 6,223 Btu/lb.

The RHV for white spruce cordwood (MC30), given the variables in Appendix B, is calculated at 12.22 million Btu per **cord**, and the DHV, which is a function of boiler efficiency (assumed to be 75%), is 9.165 million Btu per cord. The delivered heating value of **1 cord** of white spruce cordwood (MC30) equals the delivered heating value of **85.5 gallons** of #1 fuel oil when the wood is burned at 75% conversion efficiency and the oil is burned at 80% efficiency.

A more thorough discussion of the heating value of wood can be found in Appendix B and Appendix D.

SECTION 4. WOOD-FUELED HEATING SYSTEMS

4.1 Low Efficiency High Emission (LEHE) Cordwood Boilers

Most manual outdoor wood boilers (OWBs) that burn cordwood are relatively low-cost and can save fuel oil but have been criticized for low efficiency and smoky operation. These could be called low efficiency, high emission (LEHE) systems and there are dozens of manufacturers. In 2006, the State of New York instituted a moratorium on new LEHE OWB installations due to concerns over emissions and air quality[5]. Other states have also considered or implemented new regulations[6,7,8,9]. Since there are no standards for OWBs ("boilers" and "furnaces" were exempt from the 1988 EPA regulations[10]), OWB ratings are inconsistent and can be misleading. Prior to 2006, standard procedures for evaluating wood boilers did not exist, but test data from New York, Michigan, Vermont and elsewhere showed a wide range of apparent [in]efficiencies and emissions among OWBs.

In 2006, a committee was formed under the American Society for Testing and Materials (ASTM) to develop a standard test protocol for OWBs[11]. The standards included uniform procedures for determining performance and emissions. Subsequently, the ASTM committee sponsored tests of three common outdoor wood boilers using the new procedures. The results showed efficiencies as low as 25% and emissions **more than nine times** the standard for other industrial boilers. Obviously, these results were deemed unsatisfactory and new OWB standards were called for.

In a news release dated January 29, 2007[12], the U.S. Environmental Protection Agency announced a new voluntary partnership agreement with 10 major OWB manufacturers to make cleaner-burning appliances. The new phase-one standard calls for emissions not to exceed 0.60 pounds of particulate emissions per million Btu of heat **input**. The phase-two standard, which will follow 2 years after phase-one, will limit emissions to 0.30 pounds per million Btus of heat **delivered**, thereby creating an efficiency standard as well.

To address local and state concerns over regulating OWB installations, the Northeast States for Coordinated Air Use Management (NeSCAUM), and EPA have developed model regulations that recommend OWB installation specifications, clean fuel standards and owner/operator training. (http://www.epa.gov/woodheaters/ and http://www.nescaum.org/topics/outdoor-hydronic-heaters)

Implementation of the new standard will improve air quality and boiler efficiency but will also increase costs as manufacturers modify their designs, fabrication and marketing to adjust to the new standards. Some low-end models will no longer be available.

4.2 High Efficiency Low Emission (HELE) Cordwood Boilers

In contrast to low efficiency, high emission cordwood boilers there are a few units that can be considered high efficiency, low emission (HELE). These systems are designed to burn cordwood fuel cleanly and efficiently, mostly by employing gasification technology.

Table 4-1 lists three HELE boiler suppliers, all of which have units operating in Alaska. BioHeatUSA (formerly TarmUSA) and Greenwood and have a number of residential units operating in Alaska, and a Garn boiler manufactured by Dectra Corporation is used in Dot Lake, AK to heat several homes and the washeteria, replacing 7,000 gallons per year (gpy) of fuel oil.[14] Two Garn boilers were recently installed in Tanana, AK to provide heat to the washeteria and water plant, and two others were installed near Kasilof. Several more are being planned for other installations in other communities.

Table 4-1. HELE Cordwood Boiler Suppliers

Supplier	Btu/hr ratings	Brands
Bio Heat USA www.bioheatusa.com	100,000 to 198,000	Tarm, Scandtec, Froling
Greenwood www.greenwoodusa.com	100,000 to 300,000	Greenwood
Dectra Corp. www.garn.com	350,000 to 950,000	Garn

Note: Listing of any manufacturer, distributor or service provider does not constitute an endorsement.

Table 4-2 shows the test results for a high efficiency boiler that was tested at 157,000 to 173,000 Btu per hour using the new ASTM testing procedures, compared with EPA standards for wood stoves and boilers. It is important to remember that wood fired boilers are not entirely smokeless; even very efficient wood boilers may smoke for a few minutes on startup.[4,15]

Table 4-2. Emissions from Wood Heating Appliances

Appliance	Emissions (grams/1,000 Btu delivered)
EPA Certified Non Catalytic Stove	0.500
EPA Certified Catalytic Stove	0.250
EPA Industrial Boiler (many states)	0.225
GARN WHS 1350 Boiler*	0.179

Source: Intertek Testing Services, Michigan, March 2006.
Note: *With dry oak cordwood; average efficiency of 75.4% based upon the high heating value (HHV) of wood

Other gasification-style wood boiler manufacturers and/or suppliers include Econoburn, Wood Gun, TurboBurn, and EKO-Line. (And there may be others.) However, there are no known operating units by these suppliers in Alaska, and it is unknown whether any of the appliances sold by these suppliers meet the EPA standards discussed in Section 4.1.

4.3 Bulk Fuel Boiler Systems

The term "bulk fuel" as used in this report refers, generically, to sawdust, wood chips, shavings, bark, pellets, etc. Since the availability of bulk fuel is non-existent in Stevens Village, the cost of bulk fuel systems is so high (i.e., $1 million and up), and the relatively small heating demand for the facilities under consideration, the discussion of bulk fuel boiler systems has been omitted from this report.

SECTION 5. SELECTING THE APPROPRIATE SYSTEM

Selecting the appropriate heating system is, primarily, a function of heating demand. It is generally not feasible to install automated bulk fuel systems in/at small facilities, and it is likely to be impractical to install cordwood boilers at very large facilities. Other than demand, system choice can be limited by fuel availability, fuel form, labor, financial resources, and limitations of the site.

The selection of a wood-fueled heating system has an impact on fuel economy. Potential savings in fuel costs must be weighed against initial investment costs and ongoing operating, maintenance and repair (OM&R) costs. Wood system costs include the initial capital costs of purchasing and installing the equipment, non-capital costs (engineering, permitting, etc.), the cost of the fuel storage building and boiler building (if required), the financial burden associated with loan interest, the fuel cost, and the other costs associated with operating and maintaining the heating system, especially labor.

5.1 Comparative Costs of Fuels

Table 5-1 compares the cost of #1 fuel oil to white spruce cordwood (MC30) In order to make reasonable comparisons, costs are provided on a "per million Btu" (MMBtu) basis.

Table 5-1. Comparative Cost of Fuel Oil vs. Wood Fuels

FUEL	RHV[a] (Btu)	Conversion Efficiency[a]	DHV[a] (Btu)	Price per unit ($)	Cost per MMBtu (delivered, ($))
Fuel oil, #1, (per 1 gallon)	134,000	80%	107,200 per gallon	5.00/gallon	46.642
				5.50	51.306
				6.00	55.970
White spruce, (per 1 cord, MC30)	12.22 million	75%	9.165 million	250/cord	27.278
				275	30.005
				300	32.733

Notes:
[a] from Appendix D

5.2(a) Cost per MMBtu Sensitivity – Cordwood

Figure 5-1 (next page) illustrates the relationship between the price of white spruce cordwood (MC30) and the cost of delivered heat (the slanted line). For each $10 per *cord* increase in the price of cordwood, the cost per million Btu increases by $1.091. The chart assumes that the cordwood boiler delivers 75% of the RHV energy in the cordwood to useful heat and that oil is converted to heat at 80% efficiency. The dashed lines represent #1 fuel oil at $5.00, $5.50 and $6.00 per gallon ($46.642, $51.306 and $55.970 per million Btu respectively).

At high efficiency, heat from white spruce cordwood (MC30) at $440.30 per cord is equal to the cost of #1 fuel oil at $5.15 per gallon (i.e., $48.041 per MMBtu), before considering the cost of the equipment and operation, maintenance and repair (OM&R) costs. At 75% efficiency and $250 per cord, a high-efficiency cordwood boiler will deliver heat at about 56.8% of the cost of #1 fuel oil at $5.15 per gallon ($27.278 versus $48.041 per MMBtu). Figure 5-1 indicates that, at a given efficiency, savings increase significantly with decreases in the delivered price of cordwood and/or with increases in the price of fuel oil.

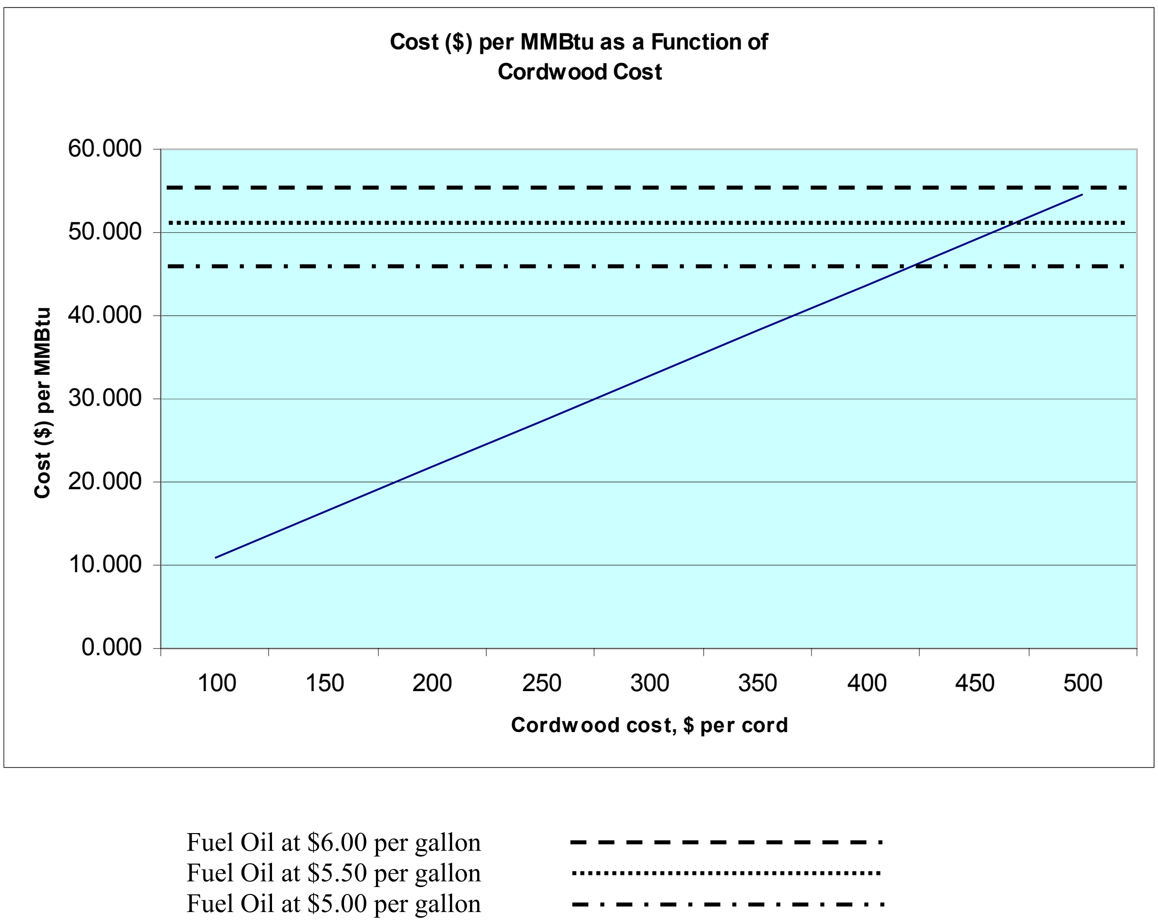

Figure 5-1. Effect of White Spruce Cordwood Price on Cost of Delivered Heat

5.2(b) Cost per MMBtu Sensitivity – Bulk Fuels

Not included in this report

5.3 Determining Demand

Table 5-2 shows the reported approximate amount of fuel oil used by the facilities in Stevens Village, Alaska.

Table 5-2. Reported Annual Fuel Oil Consumption, Stevens Village, AK		
Facility	**Reported Annual Fuel Consumption**	
	Gallons	*Cost ($) @ $5.15/gallon*
Water plant / washeteria, clinic and offices	8,300	42,745

Wood boilers, especially cordwood boilers, are often sized to displace only a portion of the heating load since the oil system will remain in place, in standby mode, for "shoulder seasons" and peak demand. Fuel oil consumption for the Stevens Village facilities was compared with heating demand based on heating degree days (HDD) to determine the required boiler capacity (RBC) for heating only on the coldest 24-hour day (Table 5-3). While there are many factors to consider when sizing heating systems it is clear that, in most cases, a wood system of less-than-maximum size could still replace a substantial quantity of fuel oil and save money.

NOTE: For the water plant/washeteria and clinic/office building, required boiler capacity for heating cannot be determined because most of the fuel is used to heat water for domestic consumption. However, Table 5-3 was prepared as if all the oil was used for space heating.

Typically, installed oil-fired heating capacity at most sites is two-to-four times the demand for the coldest day, and it appears that the water plant/washeteria boiler system falls within this range, (although, as noted, most of this capacity is applied to heating water for treatment for domestic consumption).

Manual HELE cordwood boilers equipped with special tanks for extra thermal storage can supply heat at higher than their rated capacity for short periods. For example, while rated at 950,000 Btu/hr (heat into storage), a Garn WHS 3200 can store more than two million Btu, which, theoretically, would be enough to heat the water plant, washeteria and clinic/office building during the coldest 24-hour period for nearly 8 hours (2,064,000 ÷ 268,049) (NOTE: This assumes that all oil consumption is used for space heating, which is not the case. The amount of heat required for water treatment and domestic use is beyond the scope of this preliminary assessment.)

Table 5-3. Estimate of Heat Required in Coldest 24-Hour Period

Facility	Fuel Oil Used gal/year[a]	Heating Degree Days[d]	Btu/DD[c]	Design Temp[d] F	RBC[e] Btu/hr	Installed Btu/hr[a]
Water plant, washeteria, clinic, offices	8,300	15,528	57,300	-47 (Fairbanks)	268,049[f]	1,065,000

Table 5-3 Footnotes:

[a] From SOI and site visit; net total Btu/hr

[b] NOAA, July 1, 2005 through June 30, 2006: ftp://ftp.cpc.ncep.noaa.gov/htdocs/products/analysis_monitoring/cdus/degree_days/archives/Heating%20degree%20Days/Monthly%20City/2006/jun%202006.txt

[c] Btu/DD= Btu/year x oil furnace conversion efficiency (0.85) /Degree Days

[d] Alaska Housing Manual, 4th Edition Appendix D: Climate Data for Alaska Cities, Research and Rural Development Division, Alaska Housing Finance Corporation, 4300 Boniface Parkway, Anchorage, AK 99504, January 2000.

[e] RBC = Required Boiler Capacity for the coldest Day, Btu/hr= [Btu/DD x (65 F-Design Temp)+DD]/24 hrs

[f] RBC if all fuel oil was used for space heating purposes

According to these calculations (Table 5-3), it appears that the Stevens Village water plant, washeteria, clinic and offices could, technically, supply 100% of their heating needs with one or more high efficiency low emission cordwood boilers. However, consultation with a qualified engineer is required.

5.4 Summary of Findings and Potential Savings

Table 5-4 summarizes the findings thus far: annual fuel oil usage, range of annual fuel oil costs, estimated annual wood fuel requirement, range of estimated annual wood fuel costs, and potential gross annual savings for the facilities in Stevens Village. [Note: potential gross annual fuel cost savings do not consider capital costs and non-fuel operation, maintenance and repair (OM&R) costs.]

Table 5-4. Estimate of Total Wood Consumption, Comparative Costs and Potential Savings

	Fuel Oil Used gal/year[a]	Annual Fuel Oil Cost (@ $ ___ /gal)			Approximate Wood Requirement[b]	Annual Wood Cost (@ $ ___ /unit)			Potential Gross Annual Fuel Cost Savings ($)		
CORDWOOD SYSTEMS		*5.00/gal*	*5.50/gal*	*6.00/gal*	Wh. spruce, MC30, CE 75%	*250/cord*	*275/cord*	*300/cord*	*Low*	*Medium*	*High*
Water plant/washeteria, clinic/office building	8,300	41,500	45,650	49,800	97.0	24,250	26,675	29,100	12,400	18,975	25,550
TOTAL	**8,300**	**41,500**	**45,650**	**49,800**	**97.0**	**24,250**	**26,675**	**29,100**	**12,400**	**18,975**	**25,550**

NOTES:
[a] From Table 5-2
[b] From Table D-3, Appendix D

SECTION 6. ECONOMIC FEASIBILITY OF CORDWOOD SYSTEMS

6.1 Initial Investment Cost Estimates

DISCLAIMER: Short of having an actual Design & Engineering Report prepared by a team of architects and/or professional engineers, actual costs for any particular system at any particular site cannot be positively determined. Such a report is beyond the scope of this preliminary assessment. However, a hypothetical, though hopefully realistic, system scenario is offered as a means of comparison. Actual costs, assumptions and "guess-timates" are identified as such, where appropriate. Recalculations of financial metrics, given different/updated cost estimates, are relatively easy to accomplish.

Wood heating systems include the cost of the fuel storage building (if necessary), boiler building (if necessary), boiler equipment (and shipping), plumbing and electrical connections (including heat exchangers, pumps, fans, and electrical service to integrate with existing distribution systems), installation, and an allowance for contingencies.

Before a true economic analysis can be performed, all of the costs (investment and OM&R) must be identified, and this is where the services of qualified experts are necessary.

Table 6-1 (next page) presents hypothetical scenarios of initial investment costs for a cordwood system in a medium-sized heating demand situation. Two examples are presented. It should be noted, however, that these scenarios are strictly hypothetical. The solutions presented here are not necessarily the best, correct, or only configurations. Consultation with qualified professionals is strongly recommended.

Buildings and plumbing/connections are the most significant costs besides the boiler(s). Building costs deserve more site-specific investigation and often need to be minimized to the extent possible. Piping from the wood-fired boiler is another area of potential cost saving. Long plumbing runs and additional heat exchangers substantially increase project costs. The exorbitant cost of hard copper pipe normally used in Alaska now precludes its use in most applications. If plastic or PEX® piping is used significant cost savings may be possible.

Allowance for indirect non-capital costs such as engineering and contingency are most important for large systems that involve extensive permitting and budget approval by public agencies. This can increase the cost of a project by 25% to 50%. For the examples in Table 6-1, a 25% contingency allowance was used.

NOTES:

a. With the exception of the list prices for Garn boilers, all of the figures in Table 6-1 are <u>gross estimates</u>.

b. The cost estimates presented in Table 6-1 do not include the cost(s) of any upgrades, repairs, or improvements to the existing heating/heat distribution system currently in place.

c. This example is based on the assumption that all current fuel oil use is used for space heating, which is NOT the actual case. Most of the fuel oil is used to heat water for treatment and domestic consumption, which may require a different set of calculations which are beyond the scope of this report. Consultation with a qualified engineer is required.

Table 6-1. Initial Investment Cost Scenario for a Hypothetical HELE Cordwood Systems

Fuel oil consumption, gallons per year		8,300 (Water plant/washeteria, clinic/office building)	
Required boiler capacity (RBC), Btu/hr		268,049	
Cordwood boiler	Garn model	(2) WHS 2000	(1) WHS 3200
	Rating -Btu/hr [e]	425,000 each; 850,000 combined	950,000
	Btu stored	2,544,000 (combined)	2,064,000
		Building and Equipment (B&E) Costs, **$** (for discussion purposes only)	
Fuel storage building[a] (fabric bldg, gravel pad, $25 per sf)		48,500 (97 cords @ 20 sf/cd)	
Boiler building @ $150 per sf (minimum footprint w/concrete pad)[b]		38,400 (16' x 16')	30,000 (10' x 20')
Boilers Base price[c] Shipping[d] Bush delivery [d]		 31,700 5,000 3,000	 35,000 5,000 3,000
Plumbing and electrical[d]		50,000	50,000
Installation[d]		25,000	25,000
Subtotal - B&E Costs		**201,600**	**196,500**
Contingency (25%)[d]		**50,400**	**49,125**
Grand Total		**252,000**	**245,625**

Notes:
[a] A cord occupies 128 cubic feet. If the wood is stacked 6½ feet high, the area required to store the wood is 20 square feet per cord.
[b] Does not allow for any fuel storage within the boiler building
[c] List prices, Alaskan Heat Technologies, October 2008
[d] "guess-timate"; for illustrative purposes only
[e] Btu/hr into storage is extremely fuel dependent. The data provided for Garn boilers by Dectra Corp. are based on the ASTM standard of split, 16-inch oak with 20 percent moisture content and reloading once an hour.

6.2 Operating Parameters of HELE Cordwood Boilers

A detailed discussion of the operating parameters of HELE cordwood boilers can be found in Appendix F.

6.3 Hypothetical OM&R Cost Estimates

The primary operating cost of a cordwood boiler, other than the cost of fuel, is labor. Labor is required to move fuel from its storage area to the boiler building, fire the boiler, clean the boiler and dispose of ash. For purposes of this analysis, it is assumed that the boiler system will be operated every day for 210 days (30 weeks) per year between mid-September and mid-April. Table 6-2 presents labor/cost estimates for various HELE cordwood systems. A detailed analysis of labor requirement estimates can be found in Appendix F.

Table 6-2. Labor/Cost Estimates for HELE Cordwood Systems		
System	(2) WHS 2000 (97 cds/yr)	(1) WHS 3200 (97 cds/yr)
Total Daily labor (hrs/yr)[a] (hrs/day X 210 days/yr)	132.53	97.0
Total Periodic labor (hrs/yr)[b] (hrs/wk X 30 wks/yr)	97	97
Total Annual labor (hrs/yr)[b]	40	20
Total labor (hrs/yr)	269.53	214.0
Total annual labor cost ($/yr) (total hrs x $20)	**5,390.60**	**4,280.00**

Notes:
a From Table F-2, Appendix F
b From Appendix F

There is also an electrical cost component to the boiler operation. An electric fan creates the induced draft that contributes to boiler efficiency. The cost of operating circulation pumps and/or blowers would be about the same as it would be with the oil-fired boiler or furnaces in the existing heating system. The electrical cost estimate is based on a formula of horsepower multiplied by operating time multiplied by the electric rate.

Lastly there is the cost of wear items, such as fire brick, door gaskets, water treatment chemicals, etc. For the following examples, a value of $1,000 per boiler is used.

Table 6-3. Summary of Total Annual Non-Fuel OM&R Cost Estimates		
Item	Cost/Allowance ($)	
	(2) WHS 2000 (97 cds/yr)	(1) WHS 3200 (97 cds/yr)
Labor	5,391	4,280
Electricity[a]	2,968	951
Maintenance/Repairs	2,000	1,000
Total non-fuel OM&R ($)	**10,359**	**6,231**

Notes:
a Electrical cost based on a formula of horsepower x kWh rate x operating time. Assumed kWh rate = $1.10

6.4 Calculation of Financial Metrics

Biomass heating projects are viable when, over the long run, the annual fuel cost savings generated by converting to biomass are greater than the cost of the new biomass boiler system plus the additional operation, maintenance and repair (OM&R) costs associated with a biomass boiler (compared to those of an oil- or gas-fired boiler or furnace).

Converting from an existing boiler to a wood biomass boiler (or retrofitting/integrating a biomass boiler with an existing boiler system) requires a greater initial investment and higher annual

OM&R costs than for an equivalent oil or gas system alone. However, in a viable project, the savings in fuel costs (wood vs. fossil fuel) will pay for the initial investment and cover the additional OM&R costs in a relatively short period of time. After the initial investment is paid off, the project continues to save money (avoided fuel cost) for the life of the boiler. Since inflation rates for fossil fuels are typically higher than inflation rates for wood fuel, increasing inflation rates result in greater fuel cost savings and thus greater project viability.[17]

The potential economic viability of a given project depends not only on the relative costs and cost savings, but also on the financial objectives and expectations of the facility owner. For this reason, the impact of selected factors on potential project viability is presented using the following metrics:

- Simple Payback Period
- Present Value (PV)
- Net Present Value (NPV)
- Internal Rate of Return (IRR)

Total initial investment costs include all of the capital and non-capital costs required to design, purchase, construct and install a biomass boiler system in an existing facility with an existing furnace or boiler system.

A more detailed discussion of Simple Payback Period, Present Value, Net Present Value and Internal Rate of Return can be found in Appendix E.

6.5 Simple Payback Period for HELE Cordwood Boilers

Table 6-4 presents a Simple Payback Period analysis for a hypothetical HELE cordwood boiler installation.

Table 6-4. Simple Payback Period Analysis for Hypothetical HELE Cordwood Boiler Systems

	(2) WHS 2000 (97 cds/yr)	(1) WHS 3200 (97 cds/yr)
Fuel oil cost, $ per year @ $5.15 per gallon	42,745 (8,300 gal)	
Cordwood cost $ per year @ $250 per cord	24,250 (97 cds)	
Annual Fuel Cost Savings, $/yr	18,495	
Total Investment Costs [b], $	252,000	245,625
Simple Payback Period[c] (yrs)	**13.63**	**13.28**
Annual, Non-fuel OM&R costs[a]	10,359	6,231
Net Annual Savings ($) (Annual Cash Flow)	8,136	12,264

Notes:
a From Table 6-3
b From Table 6-1
c Total Investment Costs divided by Annual Fuel Cost Savings

While simple payback has its limitations in terms of project evaluations, one of the conclusions of the Montana *Biomass Boiler Market Assessment* was that viable projects had simple payback periods of 10 years or less.[17]

6.6 Present Value (PV), Net Present Value (NPV) and Internal Rate or Return (IRR) Values for Hypothetical HELE Cordwood Boiler Installations

Table 6-5 presents PV, NPV and IRR values for hypothetical HELE cordwood boiler installations.

Table 6-5. PV, NPV and IRR Values for Hypothetical HELE Cordwood Boilers Installations

	(2) WHS 2000 (97 cds/yr)	(1) WHS 3200 (97 cds/yr)
Discount Rate[a] (%)	3	
Time, "t", (years)	20	
Initial Investment ($)[b]	252,000	245,625
Annual Cash Flow($)[c] (Net Annual Savings)	8,136	12,264
Present Value (of expected cash flows, $ at "t" years)	121,043	182,457
Net Present Value ($ at "t" years)	-130,957	-63,168
Internal Rate of Return (% at "t" years)	-3.85	-0.01
See Note #_ below	1	2

Notes:
[a] real discount (excluding general price inflation) as set forth by US Department of Energy, as found in NIST publication NISTIR 85-3273-22 (Rev 5/08), Energy Price Indices and Discount Factors for Life Cycle Cost Analysis, April 2008
[b] From Table 6-1
[c] Equals annual cost of fuel oil minus annual cost of wood minus annual non-fuel OM&R costs (i.e., Net Annual Savings)

Note #1. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $121,043 today (PV), which is less than the hypothetical initial investment of $252,000. The resulting NPV of the project is -$130,957, which means that the project, given the stated assumptions and cost estimates, will not achieve the stated return [i.e., 3%] at the end of 20 years. Given the assumptions and cost estimates for this example, this project does not appear to be cost-effective, strictly on a financial returns basis.

Note #2. With a real discount rate of 3.00% and after a span of 20 years, the projected cash flows are worth $182,457 today (PV), which is less than the hypothetical initial investment of $245,625. The resulting NPV of the project is -$63,168, which means that the project, given the stated assumptions and cost estimates, will not achieve the stated return [i.e., 3%] at the end of 20 years. Given the assumptions and cost estimates for this example, this project does not appear to be cost-effective, strictly on a financial returns basis.

These financial metrics would not classify this project as a "good investment", even though it is possible to save money by installing a wood-fired system. Annual cash flows *will* increase as oil prices continue to increase above the general rate of inflation and/or disproportionately to the cost of wood fuel. In the example of a single Garn 3200, given fuel oil prices at $6.00 per gallon and wood at $250/cord, the PV, NPV, IRR and simple payback period would be $287,418, $41,793, 4.77% and 9.61 years respectively, making the project significantly more cost-effective.

SECTION 7. ECONOMIC FEASIBILITY OF BULK FUEL SYSTEMS

The discussion of bulk fuel systems is not included in this report

SECTION 8. CONCLUSIONS

This report discusses conditions found "on the ground" at two facilities in Stevens Village, Alaska, and attempts to demonstrate, by use of realistic, though hypothetical, examples, the feasibility of installing one or more high efficiency, low emission cordwood boilers to provide heat to these facilities.

The facilities in Stevens Village consist of two distinct entities that could be served by a common (i.e., shared) cordwood boiler installation. These facilities are described in greater detail in Section 1.3, and include:

1. Stevens Village IRA Council office and health clinic
2. Water plant/washeteria

Before proceeding with a new wood-fired boiler installation, a determination must be made regarding the construction of a new water plant / washeteria. It would make little sense to construct a new heat plant now if a new water plant will be built in the near future.

In terms of siting a central heat plant, there appears to be adequate space in close proximity to the existing facilities – either in front of the existing facilities or behind them. Site preparation work would be minimal.

Typically, the greater the amount of fuel oil displacement, the better the cost-effectiveness of a given project. Unfortunately, this proposed project does not appear to be large enough to achieve that economy of scale. Given the stated assumptions, the financial metrics fall below the level of what is generally considered "cost-effective" (Section 6.5 and 6.6). However, there may be other non-monetary, societal benefits to be considered:

- A wood fired heating system *will* save *some* money over the oil-fired system
- Local money spent on locally procured fuelwood will circulate within the community longer than money spent to purchase oil from outside vendors
- A wood-fired heating system will create some part-time employment opportunities